Force and Motion: Student Activity Guide

Things can go faster or slower when they move. In a car, a speedometer tells how fast or slow it goes. What about things with no speedometers that just move around? To find out about this, we will measure the speed of a rolling ball. We will also explore ways to change the ball's speed. Some ways to change speed use gravity, mass, and friction. We will explain these words and ideas later.

These directions will get you started. Your teacher will be in contact to guide you and provide information.

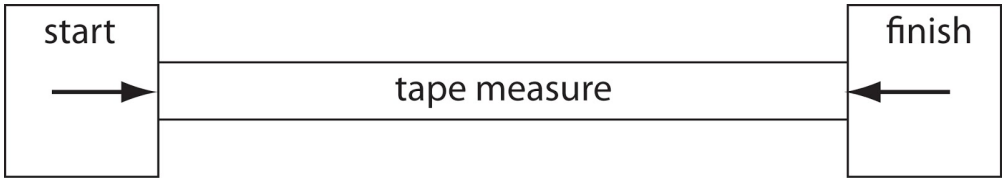
Materials From The Bag

- 1 Wooden Ball
- 1 Marble
- Salt Packet
- Tape Measure, 1 meter
- Hot Wheels Track (ramp)
- Sheet of Foam
- Food Tray (red and white design)
- Post-it Notes

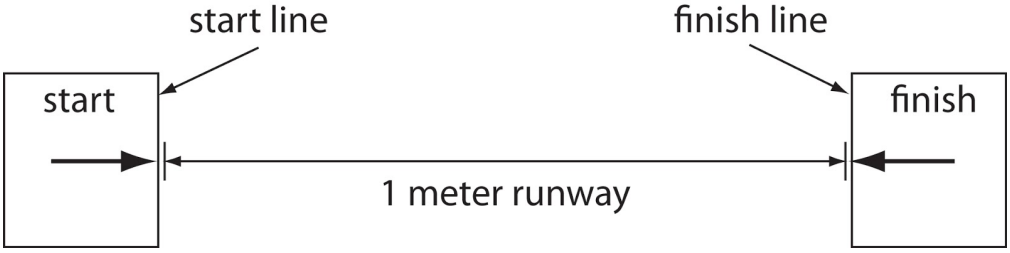
Preparation: Ramp set-up

The ramp set-up will be used in all 3 parts of this lesson.

1. Find a smooth, flat, and level place longer than a meter. Use the tape measure to be sure it's long enough. A countertop, floor, or table will work. Place a marble on the surface you will use. If the marble stays still, the surface is level enough. When you know the surface is level, return the marble to the bag.
2. Stretch out the tape measure to its full length on the flat surface.
3. Stick a post-it to the surface at both ends of the tape measure. **Put the post-it on the surface, not on the tape measure, sticky side down.** The edges of the post-it next to the tape measure are your start and finish lines. Write "Start" on one and "Finish" on the other. Draw an arrow on each post-it pointing at the tape measure, ending at the edge next to the tape measure. It looks like this:

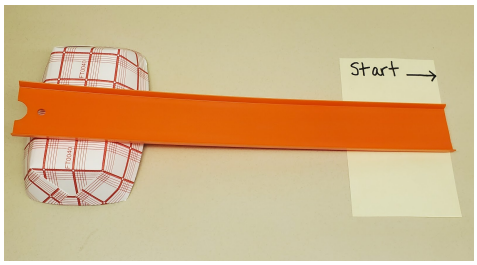


4. Remove the tape measure and leave the post-its. This is the runway. It looks like this:



5. Get the Hot Wheels track from the bag and place one end with its edge exactly on the start line.

6. Get the food tray from the bag and turn it upside down on the surface. **Lift the end of the ramp not on the start line** and slide the upside-down food tray under it so the ramp slopes down, touching the start line. Check the height of the ramp with the tape measure. It should be about 40 mm at the high edge.



7. Get the marble, place it at the top of the ramp, release, and watch the marble cross the finish line.

Part 1: Effect of Height on Speed

For the next parts, you will need a stopwatch or a timer.

Ramp A (ramp height about 40 mm)

1. Be sure your ramp is set up as shown above with the food tray under it and one end raised about 40 mm.
2. You will record how long it takes for **the marble** to travel the whole runway (1 meter).
3. To time the marble, release it from the top of the ramp and **start the timer when the marble first touches the surface (crosses the start line). Stop when it crosses the finish line.** Do this a few times to practice.
4. After practice, time the marble rolling over the runway three times. Each time, measure how many seconds (and tenths of seconds) it takes to travel one meter. Write down your results all three times.
5. After you do three trials, calculate the average time it took for the marble to travel 1 meter. To do this, add the results of all three trials and divide by the number of trials (3). Write down the average time.

Example:

Trial 1 = 2.3 seconds
Trial 2 = 2.4 seconds
\+ Trial 3 = 1.9 seconds
Total = 6.6 seconds

6.6 seconds/3 trials = 2.2 seconds to travel 1 meter (average time)

*What you think would happen if you **raised the ramp higher** and released the marble from a higher place? What would happen to the average time? Give your reasons for this.*

Ramp B (ramp height about 50 mm)

1. Adjust your ramp so the high edge (release point) is higher, about 50mm. To do this, **slide the food tray closer to the start line**. Do not roll the marble yet.
2. Predict how many seconds (and tenths of seconds) it will take for the marble to travel the whole runway (1 meter) using this ramp.
3. Follow directions above for Ramp A, steps 2-5.
4. Compare the results to your prediction. *What did you notice?*
   *What do you think would happen if you **lowered the ramp** and released the marble from a lower place?*

Ramp C (ramp height about 30 mm)

1. Adjust your ramp so the high edge (release point) is lower, about 30mm. To do this, **slide the food tray further from the start line.**
2. Predict how many seconds (and tenths of seconds) it will take for the marble to travel 1 meter using the lower ramp.
3. Follow the direction above in Ramp A, steps 2-5.
4. Compare the results to your prediction. *What did you notice?*
   How does the height of the ramp affect the time it takes for the marble to travel 1 meter?

What's happening...

You may have noticed when the ramp was higher the marble's speed was faster than when the ramp was lower. The height of the ramp affects the speed of the marble because the higher the ramp the more energy the marble has. When you release the marble, the force of gravity pulled it down the ramp. Gravity is a force that pulls any object on or near the earth toward it without touching it.

Math Extension: Measuring Speed (Distance / Time)

If someone says how fast a car is going, they might say "It's going 50 miles in an hour." They would say this even if they were only speaking of how fast it goes at that moment. However, they also mean that if you keep going exactly 50 miles an hour for a whole hour, you would go exactly 50 miles. So, people tell about speed by saying how far something goes in a certain amount of time, such as miles in an hour. They shorten that to "miles an hour" or "miles per hour." How we measure the distance and the time doesn't really matter. It could be inches per second, or in our case, "meters per second" because we are measuring distance as a meter and time in seconds. No matter what, though, **speed is always distance per time**.

How can we say how fast the marble went in meters per second? It would be easy if the marble took exactly one second to go a meter. Then we could say "one meter per second." But what if it takes 2 seconds? If it went a constant speed, then after one second, it went half of the meter, then covered the other half meter in the next second. Finally, after 2 seconds, it went the whole meter (½ meter + ½ meter = 1 meter). That means it traveled a half meter each second. So, its speed was 1/2 meter per second.

However, it's also possible to do this with math, and very easily. You might notice a pattern. Since speed is always the distance in the amount of time, the number for **speed is always the distance DIVIDED by the amount of time.** So, using math: 1 meter divided by 2 seconds is 1 divided by 2, or ½ meter per second. It's the same answer, but using math. To find the speed of your marble, divide one meter (the distance the marble

traveled) by the number of seconds it took, even if it's tenths of seconds. You might get answers with decimals in them, that's OK. Your speed can be less or more than a meter per second and it doesn't have to be a whole number of meters per second.

Part 2: Effect of Mass on Speed

For this part, **you will use a wooden ball**. The wooden ball and the marble are the same sizes, but the marble is heavier. The marble weighs 5 grams and the wooden ball weighs 1.5 grams.

1. Predict how you think the speed (the time it takes to travel 1 meter) of the wooden ball will compare to the speed of the marble?
2. Set up Ramp A (40 mm) from Part 1 and repeat the same investigation.
3. Compare your results to your prediction. *In your experiment, how did changing the mass of the ball affect the speed?*

What's happening...

Everything has mass. Mass is the amount of matter that makes up an object. The marble has more mass than the wooden ball. The amount of mass can have an effect on the speed of an object.

Part 3: Friction Forces

For this investigation use the **marble** and the ramp set-up from **Part 1, Ramp A** (a ramp height of about 40 mm).

1. Place the foam sheet just under the bottom of the ramp so the marble travels on the foam for part of the meter.
2. Predict how you think the speed of the marble rolling over the foam sheet will compare to your results from Part 1, Ramp A (no foam)?
3. Follow steps 2-5 from **Part 1, Ramp A**.
4. Compare your results to your prediction. *How did the speed change when the marble ran across the foam sheet? What do you think could cause the difference?*

What's happening...

When two objects rub against each other, the motion creates **friction** between them. **Friction is a force** that works against the motion and acts in the opposite direction. Friction can cause an object to slow down, even stop, and change directions.

5. Follow steps 2-5 from Part 1, Ramp A. Explore how friction can affect the speed of the marble by replacing the foam sheet with:
    - a piece of paper just under the end of the ramp with a small sprinkle of salt on the paper. *What do you predict will happen to the speed of the marble? How did the results compare to your prediction? How did the speed change when the marble ran across the sheet with salt?*
    - a piece of paper just under the end of the ramp with a lot of salt. *What do you predict will happen to the speed of the marble? How did the results compare to your prediction?*

    Write an explanation, using the term friction, to explain how salt affected the marble.